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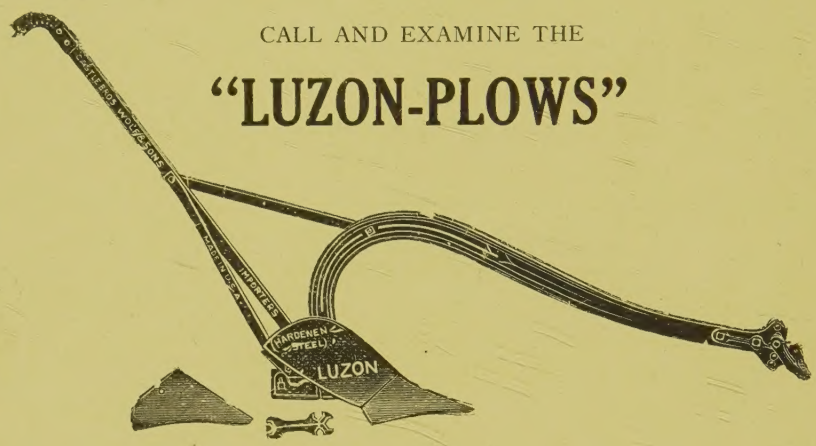

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Vol. III 1914 No. 2

The Changes Occurring in the Ripening Coconut

By Bienvenido Maria Gonzalez y Sioco

Thesis presented for Graduation from the College of Agriculture No. 12

The changes occurring in the ripening coconut have never been the object of thorough study. Walker[1] investigated the changes in the amount of copra and oil in nuts of varying ages, all more or less mature and ready for the making of copra. His results are summarized in the table below:

TABLE NO. 1.

Nuts.	% Anhydrous Copra or dry matter.	% Water.	% Oil in Endosperm.
Average of 10 nuts, fresh from trees, but fairly ripe (all green husks)	46.5	53.5	30.45
Average of 10 nuts, very ripe, (dead brown husks)	52.0	48.0	31.47
Average of 10 nuts, stored three months, just beginning to sprout	51.3	48.7	31.47
Average of 10 nuts, stored six months, which had not sprouted	40.7	59.3	27.27

There is a noticeable increase in the amount of oil as the nut reaches full maturity i. e., when the husk becomes "dead-brown" in color. This period, apparently, is when the nut has its maximum oil content. This amount is not materially changed by allowing the nuts to stand for as much as three months longer, even if germination has begun. A still longer standing, nuts not sprouting, materially decreases the oil content, or perhaps the very fact that certain nuts do not sprout indicates that their composition has been abnormal from the first.

Table I is recalculated from Walker's tables using his figures for the per cent of copra and per cent water, but basing the per cent of oil on the weight of meat instead of the total weight of the nut.

This paper will deal with the changes in size, weight, and color of the nut and the chemical changes in the milk and solid endosperm.

[1] The Coconut and its Relation to the Production of Coconut Oil. Phil. Journal of Science, Vol. I, Nos. 1, 2 and 3, 1906.

The methods of analysis used, unless otherwise specified, are those prescribed in Bull. 107, Revised, Bureau of Chemistry, U. S. Dept. of Agriculture. For convenience all the nuts analyzed will be numbered. The same nut may appear in a number of tables, but always with the same number attached.

CHANGES IN COLOR, SIZE, AND WEIGHT

Upon the opening of the flower cluster the embryonic nuts, which are really the female flowers, appear towards the base of the flower stalk as irregularly round bodies of a yellow color. On exposure to the sun they acquire a dark green color. This is preserved till full size is nearly attained, when they gradually turn yellow, and finally brown.

Size gives a valuable indication of the relative maturity of young nuts. But from the time the nut contains only a film of the meat substance till it is fully formed, the growth is gradual; and since different trees produce nuts which attain different sizes, this factor can not be relied upon as an indication of the relative maturity of a nut.

Measurements were taken on the diameter formed by the main axis, and on the longest diameter perpendicular to this. Similar measurements were taken on the shell. The results on a few typical nuts, arranged in order of increasing age, are given here:

The ones numbered from 19 to 12 had all green husks, and with the exception of 14 and 13 were all taken from the same tree. Examining the figures for the first four nuts and for No. 12, it is seen that there is a gradual increase in all diameters. Nut 14 comes from another tree, and though not so fully matured as 12 is larger than it. These figures point out that the size of young nuts from the same tree is a good indication of relative age, but not that of old nuts, nor of nuts from different trees.

The series in Table No. 3 were taken from the same tree; 7 and 9 from the same cluster, and 6 and 8 from another. 6 and 8 were fully matured and ready for picking. Size in this case will tell nothing, for it is evident that the younger nuts are larger than the older ones.

In the case of the shell of the young nuts the longitudinal diameter is greater than the transverse diameter. As the nut grows older the transverse diameter becomes the greater. This relationship is well established for all the nuts examined. In a slight degree the same

TABLE NO. 2.

No.	Relative Age	Diameters of Husks Longitudinal cm.	Diameters of Husks Transverse cm.	Diameters of Shell Longitudinal cm.		Diameters of Shell Transverse cm.
19	Youngest Green	13.1	10.1	7.5	>	5.4
18	" "	15.2	14.0	9.4	>	9.1
17	" "	16.5	14.2	10.1	>	9.8
16	" "	17.8	16.2	10.4	<	12.1
14	" "	20.0	18.7	11.5	<	12.4
13	" "	18.3	15.7	10.2	<	11.2
12	Oldest Brown	18.5	18.3	11.2	<	12.8

TABLE NO. 3.

		Color.			
7	Young Makapuno	Green and brown	10.1	<	10.8
9	Young Coconut	" " "	10.1	<	10.6
6	Older Makapuno	Brown	9.5	<	10.2
8	Older Coconut	"	9.4	<	10.4

facts apply to the husk also, but measurements on a larger number of nuts, or those grown under different conditions might have given different results.

The measurements listed below were made on nuts from different trees on an area of about a hectare, arranged as before in the order of increasing age[1].

Tables 6 and 7 show the changes in weight of the different parts of the nut during growth.

TABLE NO. 4.

No.	Remarks.	Husk Diameters Longitudinal cm.	Husk Diameters Transverse cm.	Shell diameters. Longitudinal cm.	Shell diameters. Transverse cm.
19	Green, very young, no meat	13.1	10.1	7.5	5.4
21	Green, older than 19, no meat	14.0	11.3	8.5	5.0
22	Green, meat 0.2 cm. thick	17.0	17.5	11.0	12.0
24	Green, meat 0.25 cm. thick	18.2	18.4	10.7	12.2
23	Green, meat 0.3 cm. thick	18.5	18.8	10.9	12.7

TABLE NO. 5.

5	Young green nut	9.3	9.0
4	Older green nut	10.0	9.8
3	Ripe nut with husk beginning to dry	10.1	10.1
2	Ripe nut with thoroughly dried husk	10.1	10.4

TABLE NO. 6.

No.	Remarks	Thickness of meat cm.	Weight of nut gr.	% Husk and Shell	% Solid Endosperm.	% Milk	Sp. gr. of milk.
19	Youngest, green, no meat	0	590	85.1	0	14.9	1.012
18	Next young, green, no meat	0	1362	74.7	0	25.3	1.014
17	Green, no meat	0	1622	74.1	0	25.9	1.014
16	Meat in film, watery when removed	0.10	2280	72.3	1.2	26.5	1.017
15	Green, meat harder than 16	0.10	3394	73.1	1.6	25.3	1.015
13	Green	0.35	3091	73.8	5.4	20.8	1.020
12	Oldest, brown, meat hard	1.20	1092	44.9	32.4	22.7	1.012

TABLE NO. 7.

11	Youngest, green, no meat, small nut	0.0	672	88.8	0.0	11.2	1.009
10	Green, soft meat	0.7	2747	80.5	7.5	12.0	1.023
9	Green and brown, meat rather hard	1.2	1252	67.3	20.3	12.4	1.017
8	Oldest, brown, meat hard	1.4	915	64.6	26.2	9.2	1.015

A calculation based on the figures of Table 6 from Nos. 19 to 15 would show an increase in total weight of each constituent during ripening. These nuts were all taken from the same tree. The per cent of husk plus shell decreases as the nut matures, while the per cent of solid endosperm and milk increases. Irregular changes from the normal occur when the meat has reached a thickness of about 8 mm. The solid endosperm, in quantity, thickness, and hardness, continues to increase steadily until full maturity. Results in Table 6 are supported by Table 7. I have used the color, weight and texture of old nuts, and the size of younger ones as indices in arranging the nuts in the order of relative age.

[1] See aso tables 2 and 3.

Another method for determining age is by taking the specific gravity of the whole fruit. This was tried with success, but no sufficient number of determinations were made to be worth recording here. Old nuts float in water while young nuts sink.

The specific gravity of the juice, which has increased gradually till as high as 1.023, diminishes to as low as 1.012 in the old nut, a figure just equal to the specific gravity of the milk of some very young nuts weighing scarcely 600 grams, and having less than 100 cc. of milk. In the older nuts the total weight of milk diminishes considerably. There is also a sudden falling in the weight of the nut due to loss in weight of the husk.

CHEMICAL CHANGES IN THE MILK

The milk is normally acid in its reaction. This is probably due to the carbon dioxide dissolved in it. A quantitative analysis of the gases dissolved in the coconut water, as given by de Kruyff[1], appears below:

TABLE NO. 8.

	Quantity of gas dissolved in 100 cc. of water, 7-27°.	% of CO_2 in total gas	Oxygen in cc.	Nitrogen in cc.
Young nut	0.5	98%	....	....
Ripe nut	24.0	98%	0.2	0.3

The acidity in the juice increases during the early stages of maturity, and is greatest at the time the meat begins to form; it decreases with further development. The content of amino acids varies in much the same way as does the acidity; there is a gradual rise until the endosperm begins to form, and then an irregular fluctuation tending toward a decrease.

The following table shows the changes in specific gravity, acidity, and content of amino acids of the milk during ripening. The method used in determining the amino acids was to treat a quantity of neutralized milk with neutral formaldehyde solution in excess, afterward to titrate the acid set free.[2]

TABLE NO. 9.

No.	Color	Meat Thickness c.m.	Sp. Gr.	Acidity in 100 cc. expressed as cc. N/10 acid.	Cc. N. 10 alkali used in titrating am acids in 100 c.c.	Grams amino acids in 100 cc. ino expressed as glycocoll.
19	Green	0	1.012	12.056	0.843	0.0063
18	"	0	1.014	14.619	3.111	.0234
17	"	0	1.014	14.545	3.500	.0263
16	"	0.08	1.017	14.117	2.761	.0207
15	"	0.10	1.015	13.245	5.393	.0405
14	"	0.20	1.014	7.545	3.656	.0274
13	"	0.35	1.020	10.630	6.054	.0454
03	"	1.15	1.016	7.778	6.223	.0467
12	Brown	1.20	1.012	8.685	3.487	.0262

[1] De Kruyff: Quelques recherches sur la composition de l'eau et sur les diastases du fruit de Cocos nucifera. Bull. du Depart. de l'Agriculture aux Indes Néerlandaises, No. IV, 1906.

[2] Biochem. Ztschr. *7* (1907) 48; *7*: 407; also Ztschr. physiol. Chem., *60* (1909); *64* (1910) 121.

De Kruyff[1] working with invertase and the polarimeter concludes that the young nut contains only sucrose, which is inverted in the ripe nut. Analysis of the juice of several nuts of different ages with Fehling's solution shows quite the contrary. The young nut contains only invert sugar, and with the formation of the endosperm sucrose is gradually produced, being highest in the milk of the oldest nut. Invert sugar increases as the nut matures, then diminishes with the formation of sucrose, a change which takes place at about the time the endosperm begins to develop. These changes are illustrated by the following analyses:

TABLE NO. 10.

No.	Color	Thickness of Meat.	Per cent Reducing sugars in milk.	Per cent Sucrose in milk.
19	Youngest, Green	0	1.883	0
18	" "	0	2.385	0
17	" "	0	2.627	0
16	" "	0.08	3.238	0
15	" "	0.10	3.139	.080
14	" "	0.20	2.519	.567
12	Oldest, Brown	1.20	1.454	.576

The nitrogen of the milk increases throughout growth.

TABLE NO. 11.

No.	Color.	Thickness of endosperm.	Per cent N. in Milk.	Per cent Protein (N×6.25)
19	Youngest, Green	0	0	0
18	" "	0	Trace	Trace
17	" "	0	0.0029	0.0181
16	" "	0.08	.0034	.0212
15	" "	0.10	.0058	.0362
14	" "	0.20	.0078	.0487
13	" "	0.35	.0086	.0537
12	Oldest, Brown	1.20	.0085	.0531

TABLE NO. 12.

5	Youngest, Green	0	0.015	0.0937
4	" "	Film	.023	.1437
3	" "	1.15	.028	.1750
2	Oldest, Brown	1.3	.032	.2000

TABLE NO. 13.

No.	Color	Thickness of endosperm.	Per cent N. in Milk.	Per cent Protein (N×6.25).
11	Youngest, Green	0	0	0
10	" "	0.7	0.0163	0.0978
9	" Brown	1.2	.0244	0.1525
8	Oldest, Brown	1.4	.0065	0.0416

Tables 11, 12, and 13 show how much nuts from three different trees may vary in nitrogen content. If the nitrogen analyses are compared with the determinations of amino acids a calculation will indicate that the latter make up most of the nitrogenous matter in the milk.

The percentage of total solids of the milk of the same nuts appearing in Table 12 was determined.

[1] Loc. cit.

The presence of sucrose and ash in large amounts is suggested by 9, table 14, where the large figure for total solids cannot be accounted by either the reducing sugars or the nitrogenous matter.

TABLE NO. 14.

No.		Sp. Gr.	% Reducing Sugars.	% Nitrogen.	% Total solids.
11	Youngest.....	1.012	2.870	0.015	3.711
10	"	1.015	3.485	0.023	4.271
9	"	1.016	1.790	0.028	4.868
8	Oldest.....	1.017	0.925	0.032	4.649

CHEMICAL CHANGES IN THE SOLID ENDOSPERM OR MEAT.

The meat loses water steadily till full growth is attained, and consequently gains in the per cent of total solids. Parallel with the increase in dry matter is the increase in oil content.

TABLE NO. 15.

No.	Color.	Meat Thickness	% Total Solids.	% Oil.
16	Youngest, Green.....	0.08	5.00	0.595
15	" "	0.10	5.36	0.995
14	" "	0.20	7.98	2.190
13	" "	0.35	10.31	2.780
10	" "	0.70	27.09	8.650
12	Oldest, Brown.....	1.20	46.38	24.970

At its formation the meat contains reducing sugar but no sucrose. The former decreases during ripening. The mature nut is poor in both sugars, but contains them in approximately equal amounts.

TABLE NO. 16.

No.	Color.	Meat Thickness cm.	% Reducing Sugars.	% Sucrose.
16	Youngest, Green.....	0.08	0.9051	0.0
15	" "	0.10	.5597	.0724
14	" "	0.20	.2591	.7560
13	" "	0.35	.5707	.9643
12	" Brown	1.20	.2394	.....
8	Oldest "	1.40	.1482	.1982

The following table shows that the nitrogen content of ripening nuts is subject to irregular fluctuations, with a general tendency toward a decrease:

TABLE NO. 17.

No.	Color.	Meat Thickness cm.	% Nitrogen in dry matter.
15	Youngest, Green.....	0.10	2.26
14	" "	0.20	2.89
13	" "	0.35	1.53
10	" "	0.70	1.64
12	Oldest, Brown.....	1.20	1.14

Conclusion

In summarizing the changes taking place during the ripening of a coconut we may divide the growth into three periods:

During the first period there is an accumulation of invert sugar and amino acids in the milk or watery portion. The meat is still absent, the shell and husk are soft and watery, and the nut as a whole has its greatest diameter along the main axis.

During the second period of growth sucrose appears in the milk and the specific gravity of the latter is high. During all this time water is lost from the coconut, though its total weight continues to increase. The nut has meantime changed its shape, and begins to acquire its greatest diameter in a direction at right angles to the main axis.

During the closing period of ripening there is a sudden rise in the content of oil in the endosperm. The specific gravity of the milk falls at the same time owing to the transfer of nutrient materials or to respiration. In the meantime the shell has become impervious, and the drying out of the husk results in a loss in weight, which overbalances the gain in weight due to other changes.

The coconuts on which this work was undertaken are in no way representative of really good nuts. The soil on which they grow is shallow, and the trees are poor individuals. The analyses are therefore not expected to be representative of average coconuts. The conclusions are only preliminary to further work to be done in this college.

I wish to express my thanks to Associate Professor Deming for advice and help during the progress of the work, and to Dr. Copeland for valuable criticism.

The Macapuno Coconut

By Bienvenido M. Gonzalez

The macapuno is a sport fruit of the coconut. It is little known in the Philippines outside of the provinces of La Laguna and Tayabas, and even there it is rather scarce. It has been reported occasionally from the Visayan Islands, and is well known in some parts of the Dutch East Indies.

The word Macapuno in Tagalog means full, and indicates that this coconut contains no water, but is nearly or quite full of a viscous, white, translucent jelly, whose texture next the shell more or less closely approaches the firmness of ordinary coconut meat.

No means is known whereby a tree bearing macapuno coconuts can be distinguished from one which bears normal nuts; the natives recognize their macapuno trees only by the fruit they bear. The only way of telling an unopened nut of this kind from an ordinary one is to shake it; since it contains no water no sound is made.

The fruits borne by a macapuno tree are not all macapuno. From a cluster containing about ten nuts about one to four may be gotten. The usual number is two. Natives believe that when a cluster matures during the *full moon* it is more liable to contain full nuts (macapuno). Another superstition states that a man who keeps his mouth full of boiled rice during the planting of a coconut is likely to assure the production of nuts having meat of the consistency of the rice itself.

The only fact which seems to be well established is that a tree which bears a few macapuno nuts one year is likely to do so again. It is generally believed that normal nuts from a tree which bears macapuno nuts will produce other trees of the same kind. The macapuno nuts themselves contain a well-marked embryo, but will not germinate. They soon spoil if an attempt is made to store them.

Macapuno bearing trees are often found grouped together in the older coconut groves, a fact which might be supposed to indicate some soil peculiarity as the predisposing cause of the abnormal fruit. The owners of the trees state that such is not the case, but that the nuts which came from macapuno bearing trees were purposely planted near together, in order that the expected harvest of macapuno nuts might be more easily supervised. As many of these trees are forty to fifty years old, and as no accurate planting records have been kept, it is impossible to tell whether or not such is the correct explanation.

As a preliminary study of the nature of the macapuno nut, and the way in which it differs from the ordinary coconut, an analysis is here presented, together with figures given by Semler (Tropische Agrikultur. Vol. 1, p. 617). The percentages of protein, oil, and ash have been recalculated to a moisture free basis.

	Semler's coconut		Normal nut from college farm		Macapuno nut from Mojon, La Laguna.	
	Meat.	Milk.	Meat.	Milk.	Firm outer portion.	Soft inner portion.
Water.....	46.64	91.50	63.62	95.13	71.59	90.65
Protein.....	10.79	5.41	9.09	1.09	11.76	10.69
Oil.....	67.33	0.82	68.63	Undet.	41.67	18.89
Ash.....	1.81	14.00	2.11	Undet.	1.81	3.74

The solid portion of the macapuno nut is slightly richer in protein than the common nut, but is considerably poorer in oil. The soft portion of the macapuno contains more protein and oil than does the milk of a normal nut.

The macapuno is valuable for the making of preserves. Sometimes it is eaten fresh with sugar, but is rather unpalatable unless sweetened. When boiled in syrup it is relished by all who have occasion to try it, and occupies a place with the best of Philippine sweetmeats. The supply being limited and the demand very great, the macapuno commands a price approximately five times that of the common nut.

The existence of this kind of a variation from the normal form of fruit of the coconut raises interesting questions as to the possibility of the transmission of such a characteristic; the chemical composition of the abnormal nuts needs to be more closely studied, especially the nature of the carbohydrates and proteins they contain; and there are physiological questions as to what influences have produced the sport form and why such nuts fail to germinate. A later report will be made by some one in this college, and persons interested are invited to send in any information they possess, especially as to the occurrence of this fruit in other parts of the world. Communications should be addressed to Dr. E. B. Copeland, Professor of Plant Physiology, or Dr. H. G. Deming, Associate Professor of Chemistry.

Lipase In The Germinating Coconut

By Manuel Luz Roxas.

Thesis presented for graduation from the College of Agriculture No. 11

Introduction

The formation of alcohol from a sugar solution through the action of yeast has been known from the earliest times. The name fermentation was first applied to this process, the word perhaps having its origin in a Latin expression that called to mind the apparent boiling of such a fermenting liquid, from the escape of bubbles of carbon dioxide gas. In fact all phenomena accompanied by effervescence were believed at one time to be closely related, so that the action of an acid on marble, and the putrefaction of dead bodies were believed to be but forms of fermentation.

Although at present we are in possession of an immense number of facts regarding the nature of fermentation, we are far from being able to give any clear explanation of it. Nevertheless the following facts concerning the action of yeast in fermenting sugar are well established: First, cane-sugar is not directly converted into alcohol, but is first changed into a mixture of fruit-sugar and grape-sugar, which is then further acted upon by the yeast and converted into as many as a dozen different substances, of which alcohol and carbon dioxide gas form by far the greatest part. Second, yeast that is soaked in cold water for several hours will give up to the latter some substance able to decompose cane-sugar into a mixture of the other two sugars mentioned without the intervention of any living cell. Third, yeast that has been dried and finely ground, or whose cell-membrane has been rendered permeable by the action of chloroform, may be made to yield to water a substance which can bring about the final stage of the transformation described, namely the conversion of the mixture of sugars obtained from canesugar, into alcohol and carbon dioxide.

It is plain that the transformation of cane-sugar into alcohol and carbon dioxide cannot be the result of the life-processes of the yeast-plant since the same changes can be brought about by substances separable from the yeast cell under suitable conditions. Sugar may be fermented by an extract of yeast cells which has been freed from all protoplasmic material by filtering through very fine pores, such as those of unglazed porcelain.

Now the substances contained in the yeast cell which have been shown to be responsible for the fermentation of sugar are but two of many organic bodies existing in nature having the power of bringing about chemical changes that could otherwise be made to take place only with difficulty, if at all. The protoplasm of a living organism is the seat of a series of complex chemical changes. Some of the latter are synthetic, others analytic, but many of them can be imitated by the chemist only by methods which must seem crude and laborious in comparison.

As an example of the violent efforts which must be put forth by man when he seeks to imitate some simple process occurring in nature may be mentioned the fact that the conversion of starch into glucose in the laboratory is accomplished only by boiling for several hours with a three *per cent* solution of hydrochloric acid; the same change takes place in living cells in a few minutes in a medium almost neutral, and at a moderate temperature.

Some of the chemical substances responsible for the complex reactions taking place in living organisms have been separated from the cells producing them, and have been obtained in a condition more or less pure. In other cases we are unable to prove that the chemical changes going on are due to the intervention of anything but the protoplasm itself, namely to that part of the organism which is preëminently alive. The organic substances known to be secreted for the express purpose of bringing about chemical transformations necessary for living plants or animals have been called *enzymes*. Some of the metamorphoses induced by enzymes are necessary for the liberation of energy needed in the process of growth and the rebuilding of wasted tissue; others decompose complex foods into simpler substances; still others elaborate the products of digestion into more complicated carbohydrates or proteids.

Enzymes have been classified according to the kind of material upon which they act. Thus we have those that convert insoluble carbohydrates such as starch into soluble ones such as grape-sugar, those that decompose cane-sugar and its near relatives into simpler sugars, those that digest proteid material, those that cause fats to turn rancid, and many others.

All these different types of enzymes present certain general common features. There is a minimum, optimum, and maximum temperature for the action of each. This activity is not manifested at temperatures near the freezing point of water, but increases gradually as the temperature rises. The optimum temperature ranges from thirty to fifty degrees Centigrade. Beyond this temperature the activity of all enzymes gradually decreases, and they are generally destroyed below the boiling point of water.

The destructive effect of high temperatures seems to depend in some way upon the presence of water, for if the enzymes are perfectly dry they can resist heating to a much higher point. Enzymes are very sensitive to the reaction of the solution in which they are working. Some are active only in acid, others in neutral, and others again in alkaline media. Any change in the medium may result not only in checking the activity of the enzymes but even in their destruction.

The chemical composition of enzymes is unknown, though they have been supposed by many to be of proteid-like nature. The only satisfactory test for their presence is the demonstration of the occurrence of the changes which they produce, and no satisfactory explanation of their action has yet been offered. This paper will deal with the particular enzyme called *lipase*, which is the enzyme causing fats to become rancid. This phenomenon is caused by the decomposition of the fats, by lipase, into glycerine and fatty acids, the latter being characterized by an unpleasant odor. Lipase is thus the direct cause of the rancidity of butter and lard, and is one of the factors in the deterioration of old copra. Aside from these objectionable changes, lipase plays an important and useful part in the germination of oily seeds. Its occurrence in the germinating coconut has been a matter of dispute. The following paragraphs will review some of the investigations which have been carried out with this enzyme.

Properties of Lipase

While de Kruyff[1], Lumia[2], and others found lipase in the germinating coco-

1) De Kruyff. Bull. du Dept. de l'Agric. aux Indes Néer.—IV—8 (1906).

2) Lumia. Staz. Sperim. Agrar, Ital. 31 (1898) 397, through Czapek, "Biochemie der Pflanzen"

nut, Walker[1], of the Philippines Bureau of Science, failed to establish its presence. After the publication of the results obtained by the latter, new discoveries were made concerning the existence of more than one kind of lipase, and it is in the light of such recent research that the present work was undertaken. Since the conclusions of an observer in the Philippines failed to agree with those reached elsewhere it was thought fitting that new observations should be made here.

As is well known, the presence of lipase in Ricinus was discovered by Green.[2] He ground up the germinating seeds of Ricinus with a solution of sodium chloride, and added to them 0.2% potassium cyanide as an antiseptic. He then prepared a control, which was a boiled, but otherwise similar preparation. After twenty-four hours both were titrated; the unboiled preparation indicated liberation of acid, while the control remained neutral.

Most of the properties ascribed to this enzyme have been discovered by a study of the lipase of Ricinus or of the pancreas. "The latter works best in neutral solution, but is also active in dilute alkalies, and to a much less extent in dilute acids. Comparing three digestions, the first of which was neutral, the second containing 0.066% of sodium carbonate, and the third 0.066% of hydrochloric acid, the relative activities were as 78: 69: 21. Hydrochloric acid when present in the proportion of 0.13% stopped the action almost entirely; sodium carbonate needed to be present in the proportion of 0.5% to lessen its power one-half[2]." Prolonged action of either acid or alkali not only stops the action, but destroys the enzyme. Certain neutral salts only inhibit the action, without destroying the enzyme. Loevenhart[3] established the inhibiting action of sodium fluoride in the case of pancreatic lipase, and the present paper will show that the lipase of the coconut is inhibited by potassium cyanide and sodium arsenite. The majority of the antiseptics have a more or less injurious action.

As indicated by Green's experiments, the lipase of the castor oil bean is destroyed by boiling; this is also true of pancreatic lipase, but recently Söhngen[4] has described a form of lipase which is not destroyed by even fifteen minutes boiling.

The chemical reaction induced by lipase is a reversible one. Ivanov and others[5] worked on the synthesis of fats by means of plant lipase. The author first named ground up unripe flax, poppy, and rape seeds with sand and glycerol; the extract thus obtained was mixed with oleic acid and thymol, and the change in acidity on standing determined by titration. A fat-splitting action in dilute solutions of water and glycerine and a fat-synthesis in concentrated solutions were established. Efforts to synthesise fats by means of the enzyme of the coconut have been without success.

Experimental Part

Green found lipase as a zymogen in the resting seeds of the Ricinus, or castor-bean. The zymogen was activated by him by means of a very dilute solution of acetic acid. Accordingly a similar experiment was performed with the coconut under the following conditions. About four grams of the ground foot of the germinated nut

1) Walker. Phil. Jour. Sci. 3-A (1908) 111.
2) Green. "The Soluble Ferments and Fermentation," p. 244.
3) Loevenhart. Jour. Biol. Chem.
4) Söhngen. Chem. Weekblad. 8 (1911) 580.
5) Ivanov. Ber. Bot. Ges. 29 (1912) 594-602. Dunlap and Gilbert Am. Chem. Jour. 33 (1911) 1787.

was treated with fifty cubic centimeters of tenth-normal sulphuric acid, twentieth-normal sulphuric acid, and distilled water, respectively. The samples were neutralized after twenty-four hours, and titrated on succeeding days with fifth-normal sodium hydroxide. One-tenth of a gram of KCN was used as an antiseptic. The figures in this, as in all succeeding tables, show the number of cubic centimeters of fifth-normal sodium hydroxide needed in the titration. The indicator used was phenolphthalein, or occasionally thymolphthalein.

SOL.	June 12	June 13	June 14
1-10 N. H_2SO_4.....	Neutralized.	8.6	6.5
1-20 N. H_2SO_4.....	Neutralized.	0.1	0.1
Water.....	Neutralized.	0.2	0.05

From this experiment it seems as though lipase is present as a zymogen, which may be activated by acid. The strength of the acid in the suspension is not really tenth-normal, part of the acid added having been neutralized by the potassium cyanide used.

The above experiment was repeated, using ground endosperm, with the following results:

	June 12	June 13	June. 14
1-10 N. H_2SO_4.....	Neutralized.	7.8	7.04
1-20 N. H_2SO_4.....	Neutralized.	3.8	4.16
0-00 N. H_2SO_4.....	Neutralized.	0.0	0.00

The zymogen appears to be present also in the endosperm. It is activated by both the tenth-normal and the twentieth-normal sulphuric acid, the tenth-normal acid acting most favorably.

Enzymes have been assumed by many to be of proteid nature. Since one class of proteids, the globulins, are soluble in 5% sodium chloride solution, it was thought worth while to try to extract coconut lipase with this, just as Green did with Ricinus lipase. About thirty grams of ground endosperm dried over sulphuric acid was bruised in a mortar with 150 cc. of a 5% solution of sodium chloride. The extract thus obtained was treated as follows:

	June 18	June 20
7. 50 cc. of extract, 40 cc. of 1% solution of $NaAsO_2$	Prepared.	0.9 cc. 1-5 N. Alk.
8. Duplicate of 7	,,	0.83 ,, ,, ,, ,,
9. As 7, but boiled	,,	0.6 ,, ,, ,, ,,

All were neutralized at the start. There was no action after the second day.

Experiments were next carried out with scrapings from the soft inner portion of the endosperm, using potassium cyanide in a concentration which was afterward found to have a depressing influence on the action of the enzyme.

	June 30	July 2	July 4	July 6	July 11	July 12	July 15	Totals.
16. 4 g. scrapings 0.2 g. KCN, 2.5g. NaCl, 50 cc. H_2O neutralized...	...	...	...	...	...	...	...	0.0 1-5 N.
17. Similar but boiled.....	0.8	2.4	0.7	0.7	0.7	1.2	5.8	5.8 1-5 N.

It seems rather strange that the unboiled preparation should develop no acidity, while those boiled did so. A possible explanation is that, on boiling, part of the hydrocyanic acid present was expelled, thus lowering

its concentration and diminishing its inhibiting action; or perhaps the results are to be attributed to bacteria.

In the following preparations the concentration of the potassium cyanide was decreased.

18. About four grams endosperm, 0.1g KCN, 50 cc. 1-10N. H_2SO_4, neutralized after twenty-four hours. The amount of acid added is more than sufficient to overcome the alkalinity of the KCN.

19. Similar preparation, but the endosperm was first boiled with a small amount of water, then enough acid was added to make 50 cc. of suspension, in which the acid is 1-10N; 0.1g KCN was used as antiseptic. Neutralized after 24 hours.

20. As 18, but no acid, neutralized.

21. As 18 plus 2.5g NaC1, neutralized.

	June 30	July 2	July 4	July 6	July 11	July 12	July 15	Total cc N/5 Alk
18	Neut.	1.50	7.51	1.20	3.55	2.55	3.70	20.01
19	Neut.	....	0.70	0.45	1.30	1.35	1.00	4.80
20	Neut.	2.80	....	0.75	0.55	0.20	1.00	5.10
21	Neut.	....	2.40	....	3.70	....	1.00	7.10

The favorable action of the acid is again observed. Boiling weakens, but does not destroy, the enzyme.

It has been suggested that the acid developed by the action of lipase is converted into sugar. If this be true the addition of sugar to the preparations should by mass action tend to prevent the transformation of the acid and lead to higher figures in titration. The following preparations were made to test this point:

22. About 4g endosperm, 1g thymol, 10% sodium chloride, 1-20 N. sulphuric acid. The volume of the preparation in all is 50 cc. Neutralized after 24 hours.

23. About 4g endosperm, 20g cane sugar, 0.1g KCN, a few drops olive oil, 50 cc. water, neutralized.

24. About 4g endosperm, 20g cane sugar, 1g thymol, 50 cc. water neutralized.

25. As 24 but boiled.

	June 30	July 2	July 4	July 6	July 11	July 12	July 15	Totals cc N/5 Alk
22	Neut.	12.30	2.60	0.30	0.20	....	0.40	15.80
23	.....	7.40	4.70	6.75	22.20	19.23	48.80	109.08
24	.....	2.90	4.50	1.80	2.45	0.95	2.40	15.00
25	.....	....	2.20	1.25	2.10	0.22	1.00	6.77

Number 23 developed a great acidity. This result may show that olive oil is more readily hydrolyzed than coconut oil, yet no general conclusion should be drawn from a single experiment. Preparation 25, which was boiled, still showed formation of free acid, although to a far less extent than the unboiled ones. This result tends to indicate that we have in coconut a heat-resisting lipase, such as that described by Söhngen[1].

The endosperm from one coconut was expressed and the resulting cream used in the following preparations. The amount of sulphuric acid added is enough to neutralize the sodium fluoride or the potassium cyanide added. These were prepared July 20.

		July 31.
26.	50 cc. of cream, 10 g. sugar, ¼ g. NaF, 1 cc. coconut oil, 30 cc. N-5 H_2SO_4..	0.5 cc. 0.2 N. Alk.
27.	50 cc. of cream, 10 g. cane sugar, ½ g. KCN, 1 cc. olive oil, 30 cc. N-5 H_2SO_4 (Found alkaline)...	0.7 cc. 0.2 N. acid.
28.	50 cc. cream, 10 g. cane sugar, 0.25 KCN, 1 cc. coconut oil, 5 cc. N-5 H_2SO_4, 15 cc. water.	Neutral.
29.	50 cc. cream, 10 g. cane sugar, 0.5 $NaAsO_2$, 1 cc. coconut oil.....	Neutral.
30.	50 cc. cream, 0.5 KCN, few drops coconut oil, 30 cc. N-5 H_2SO_4	0.15 cc. N-5 Acid.
31.	1 g. ground endosperm, 10 g. cane sugar, 50 cc. water, 0.5 KCN, 30 cc. N-5 H_2SO_4	0.70 cc. N-5 Acid.
32.	50 cc. cream, 0.5 KCN, a few drops of coconut oil, 30 cc. N-5 H_2SO_4, ½ hour at 90 degrees.....	0.50 cc. N-5 Acid.

(1) Söhngen, loc. cit.

33.	50 cc. cream, 0.5 KCN, a few drops coconut oil, 30 cc. N-5 H_2SO_4, ½ hour at 80 degrees.....	0.15 cc. N-5 Acid.
34.	50 cc. cream, 0.5 KCN, a few drops coconut oil, 30 cc 0.2 N. H_2SO_4, ½ hour at 70 degrees.	0.60 cc. N-5 Acid.

Titration on succeeding days indicated no formation of free acid. It is to be noted that the antiseptics were used in relatively high concentrations. The negative results, therefore, are due to the inhibiting action of the antiseptics.

The outer and inner part of the foot of a highly acid nut were tested separately for lipase action, but very slight activity was manifested. The results seem to indicate that an accumulation of the products of lipase action, or the development of acidity through the action of bacteria may finally destroy the enzyme. The details of these experiments (numbers 84 to 102) are omitted, since the acidity developed was in no case sufficient to warrant conclusions being drawn as to the relative lipolytic activity of the different portions of the foot.

On account of the fact that enzymes in general tend to be inhibited by the accumulation of the products of their own activities, the removal of the free fatty acid formed should greatly favor the action of lipase. Dr. Deming suggested the use of magnesium oxide for this purpose, since its solubility is so slight (0.001%) that the alkalinity developed should not interfere with the action of the enzyme. A known weight of magnesium oxide is added to a preparation, and the excess of alkali titrated back at the end of the experiment.

One advantage of the use of magnesium oxide is that the preparation is subjected to constant conditions, for as soon as some fatty acid is set free, it is taken up by whatever magnesium oxide has dissolved in the water. A new portion of the magnesium oxide then goes into solution. Another advantage is that the fatty acids are neutralized before they can undergo a possible transformation into something else. It is possible that the magnesium oxide helps to preserve sterile conditions, for no difficulty was found in securing cultures which developed no colonies, in the preparations containing it.

In the experiment about to be described the following abbreviations are used:

W.....Coconut water.
J.....Expressed juice from foot.
S.....25 grams of the scrapings from the endosperm macerated with two hundred cubic centimeters of water.

The preparations were allowed to stand for eighteen days, then the magnesium oxide remaining undissolved was titrated by the slow addition of standard fifth-normal acid, with constant stirring until the pink color of the phenolphthalein was discharged. The figures given in the table below were gotten by substracting the number of cubic centimeters required by a blank, not shown in the table. They are thus a measure of the amount of fatty acid set free during the experiment and combining with the magnesium oxide.

		Sept. 14	Nov. 2	Acid
104.	50 cc. J, 2 cc. oil, 2 g. thymol, neutralized; 1.002 g. MgO.....	Prep.	Neut.	125.93
105.	50 cc. J, 2 cc. oil, 2 g. thymol, neutralized; 1.008 g. MgO.....	Prep.	Neut.	145.07
106.	50 cc. S, 2 g. thymol, neutralized; 1.04 g. MgO.....	Prep.	Neut.	124.18
107.	50 cc. S, 2 cc. oil, 2 g. thymol, neutralized; 1.06 g. MgO.....	Prep.	Neut.	123.28

Experiments without magnesium oxide were performed for comparison. All preparations were neutralized at the start.

108. 50 cc. W, 2 g. thymol, 5 g. acacia.
109 50 cc. W, 10 g. sugar, 2 g. thymol, 5 g. acacia, 2 cc. oil
110 50 cc J, 2 g. thymol, 5 g. acacia.
111. 50 cc. J, 10 g. sugar, 2 g. thymol, 2 cc. oil.
112. 50 cc. S, 10 g. sugar, 2 g. thymol, 5 g. acacia.
113. 50 cc. S, 10 g. sugar, 2 g. thymol, 5 g. acacia, 2 cc. oil.
114. 50 cc. S, 10 g. sugar.

		Sept. 14	Sept. 26	Oct. 2	Oct. 22	Nov. 26	Totals
108.	Prep...	4.80	.....		2.40	0.95	8.15
109.	Prep...	7.70	.....		3.60	1.77	13.07
110.	Prep...	24.80	.....		27.70	16.58	69.08
111.	Prep...	13.90	.....		18.00	14.45	46.35
112.	Prep...	.....		12.90	11.10	17.45	41.45
113.	Prep...	.....		10.65	18.20	16.80	45.65
114.	Prep...	.....		20.50	24.50	16.40	61.40

NOTE:—114 developed a putrid odor.

It is plainly shown both in the preparations with and in those without magnesium oxide, that the outside part of the foot has the greatest lipolytic activity. Another result to be observed is the great action in the magnesium oxide preparations compared with those without it. This may be due either to the favorable condition created by magnesium oxide, or it may be possible that the latter activates the lipase just as the bile salts and several inorganic salts, as described by Loevenhart, can accelerate the action of pancreatic lipase. The expectations in the use of magnesium oxide are therefore realized.

Acacia was used in order to secure a more perfect emulsion. This method was suggested by Green. Its favorable effect is shown by comparing 110 and 111. Both are foot preparations, one containing gum acacia and the other sugar instead. The former developed more free acid than the latter.

The lipolytic activities of the inside part of foot and of the scrapings from the endosperm are about equal.

Summary

1) Lipase is present in the germinating coconut, both as an enzyme and as a zymogen which can be activated by dilute acids.

2) It is found mainly in the outer part of the foot or haustorium; smaller amounts occur in the water of the coconut and the inner surface of the endosperm.

3) Potassium cyanide and sodium arsenite when used in a concentration of 0.4% stop the action of the enzyme.

4) Thymol can be used in as high a concentration as 5% without any noticeable effect on the action of the enzyme.

5) Boiling weakens but does not destroy the enzyme.

6) Coconut lipase works best in the condition created by the addition of magnesium oxide: that is, in a practically neutral medium.

7) Attention is called to the use of magnesium oxide in the study of lipase, as constituting a valuable improvement over former methods of investigation.

In closing I desire to express my obligations to Associate Professor Deming for help in the preparation of this paper. My thanks are also due to Professor Copeland for criticism and suggestion.

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THE COMMENCEMENT OF THE UNIVERSITY OF THE PHILIPPINES

April 2nd, 1914, the Fourth Commencement Exercises of the University of the Philippines were held on the University Campus, Manila. The Hon. Rafael Palma, Member of the Philippine Commission and of the Board of Regents, delivered the Commencement address, and His Excellency, Francis Burton Harrison, Governor-General of the Philippines, a scholarly address to the graduates. Ninety-six graduates received degrees, twelve of whom were from the College of Agriculture. Marcelo Crisostomo and Nemesio B. Mendiola received the degree of Bachelor of Science in Agriculture; and Francisco A. Quisumbing, José S. Camus, José P. Tirona, Alfredo P. Adriano, Gonzalo F. Merino, Francisco G. Galang, Eutiquio Q. Zulaybar, Amando L. Laparan, Vicente G. Bartolomé, and Antonio Lejano, the degree of Bachelor of Agriculture.

THE COMMENCEMENT OF THE FOREST SCHOOL

The Third Commencement Exercises of the Philippine Forest School were held March 20th, 1914, in the Assembly Hall of the College of Agriculture, at Los Baños. Commissioner de Veyra was expected to deliver the Commencement address but was absent due to illness. However, a short exhorting address, sent by telegraph, was read to the students by the Dean. Professor Ahern, Director of the Bureau of Forestry, gave his usual advice to the new rangers. A very interesting feature of the exercises was the announcement of the first honor students of the school.

These were Placido Dacanay, Medalist, and Santiago Tomeldan and Mariano Castillo, first and second honor student respectively. The members of the year's class are as follows:

NAME.	HOME PROVINCE.	STATION.
Ramon Acuña	Albay	Zamboanga.
Marcelo Adduru	Cagayan	Vigan.
Benigno Alejandro	Nueva Ecija	Aparri.
Julio Baldemor	Laguna	Limay.
Francisco Cardona	Tarlac	Iloilo.
Mariano Castillo	Ilocos Norte	Los Baños.
Vicente Castillo	Zambales	Manila.
Placido Dacanay	La Union	Los Baños.
Jesus O. Duran	Ambos Camarines	Iloilo.
Emeterio Edmilao	Misamis	Los Baños.
Felipe Fajatin	Ilocos Sur	Naga.
Pedro Gangan	Isabela	Limay.
Carlos Guerrero	Ilocos Sur	Limay.
C. H. Hsia	China	
Filemon Kapuno	Cebu	Naga.

Gregorio J. Labitag	Sorsogon	Los Baños.
Ramon Larracas	Tayabas	Iloilo.
Antonio Martinez	Albay	Los Baños.
Pacifico Mayor	Romblon	Limay.
Gregorio Natividad	Zamboanga	Puerto Princesa.
Severo Oliveros	Laguna	Zamboanga.
Justo M. Pascual	Tarlac	Manila.
Maximiano Razon	Tarlac	Zamboanga.
Gorgonio Riego de Dios	Cavite	Zamboanga.
Tomas Roque	Pampanga	Cadiz.
Adriano Santos	Manila	Iloilo.
Crispino Tansioco	Tarlac	Naga.
Felipe Valderrama	Pangasinan	Naga.
Santiago Tomeldan	Pangasinan	Zamboanga.
Vitaliano Villavicencio	Mindoro	Limay.
José Agama	Manila	Manila.
Agapito L. Cenabre	Cagayan	Surigao.

Handling and Planting of Seed Cane

By Alfredo P. Adriano

Thesis presented for graduation from the College of Agriculture No. 13

Varieties of Cane Used

Eight varieties were used in carrying out this experiment although four consist only of a single stalk available on the college farm and supposed to have come from The Bureau of Agriculture.

1. College No. 70, Saccharum officinarum, white cane.
2. College No. 299, Saccharum officinarum, red cane.
3. College No. 896, Saccharum officinarun, white sugar cane, unas a purao, "Cambong," from La Union.
4. College No. 897, Saccharum officinarum, red sugar cane, unas a nalabaga, sailoco, from La Union.
5. College No. 1837, Saccharum officinarum, purple cane.
6. College No. 1834, Saccharum officinarum, red purple cane, Sinanduyong, from Bulakan.
7. College No. 1836, Saccharum officinarum, white cane, from Los Baños, Laguna.
8. College No. 1835, Saccharum officinarum, white cane, from Bulakan. "Zambales" is the name of this variety.

Sinanduyong Cane

This variety is characterized by having hispid-edged leaves without any hair on the surface of the leaf. The blades extend to a maximum length of 134.8 cm. and 6.4 cm. in width. The average length of usable cane runs to about 156.4 cm. with a diameter of 2.9 cm. Almost all of the canes grown in this experiment are erect though air-roots are present to about 17 cm. above the ground. The cane is purple, with a ring of waxy substance just below the nodes covering a space about one centimeter wide. The eyes are prominent and divergent. This variety is quite hard for chewing and is only used for milling.

Zambales

The Zambales cane possesses the same leaf characters as the Sinanduyong cane. The length and width of the blade reach 152.7 cm. and 4.8 cm. The usable cane has an average length of 181 cm. and a diameter of 4.5 cm These canes may be erect or sprawling on account of the weight. The air-roots may be present to about 11 cm. above the ground, thus covering two internodes. The stem is yellowish-white with red spots. It possesses cracks at the internodes which is apparently a common condition in this particular variety everywhere. Waxy coating may be seen just below the nodes. The stem

is not truly cylindrical, being a little larger at the middle of the internodes. The eyes are generally small and appressed. This variety is largely used for chewing in the province of Bulakan.

Los Baños Cane, or the White Bamboo Cane

This cane possesses characters somewhat similar to some of the above described varieties. It has a blade becoming 118 cm. in length and 8.2 cm. in width. The usable canes may be 146 cm. long, with internodes of 4.8 cm. This cane is erect and never branched. The air-roots are present and occur to about 25 cm. above the ground. The stem is white with a heavy coating of wax on the internodes. Almost all of the internode is covered with waxy substance, especially when the sheath is first removed. The eyes of the cane are large and prominent. This cane is largely used for milling in this province and regarded as the best cane for sugar manufacture.

College Cane, Purple, from Negros.

The leaves of this cane have a maximum blade length of 141.5 cm. and width of 7.2 cm. The edge is hispid and there is no hair on the surface. The length of the usable cane is about a meter, with internodes of 2.5 cm. The canes are erect with occasional branches. The air-roots are not present except on canes on which the sheaths are persistent. In such canes the air-roots occur as far above ground as 3 or 4 internodes. The stem is of a red purple color and heavily covered with wax over the internodes. The thickest coating of the waxy substance occurs just below the internodes. The eyes are large and prominent. This is the cane commonly grown in Negros and there considered the best cane for sugar manufacture.

Canes Numbers 70, 299, 896 and 897

These canes are very similar to each other. All have hispid-edged leaves without any hairs on the surface. The average lengths of the blades are 109.5 cm., 142.7 cm., 103.9 cm., and 148.2 cm. All of these canes were recently transferred from the nursery bed to this field experiment, and apart from the destruction suffered from locusts the canes failed to do well so that further description of these varieties is impossible.

Preparation of the Soil

Sugar, like all other crops, demands a thorough preparation of the land to prevent the tendency of the soil to harden. Good preparation, of course, also tends to destroy the weeds and grasses. It also controls moisture and increases the power of the soil to absorb and store up the rainfall.

In the early days of the industry, cane was mostly planted on newly cleared land where the preparation consisted mainly in felling and burning the timber. It remained to be decided whether to plow at once and plant canes among the stumps or first pull the stumps.[1] The pulling would surely be the best plan in the long run, though it demands a large capital. It also offers the advantage of having no waste land, no destruction of implements used in the preparation of the soil, and no place for the weeds and grasses to grow. Stumps may be easily and economically pulled by using wire cable stump pulling tackles, as is done by the Calamba Sugar Estate.

In the Calamba Sugar Estate only big trees were cut down. The small trees, like the common Sta. Elena, were pulled up by cable tackles. The stumps of trees of the size of an ordinary man's waist are easily pulled by cable.

Stumps were cleared away with cable steam plows. For the very big trees dynamite was used.

After the stumps are cleared cable plowing may be economically employed for working land on a large scale. The Calamba Sugar Estate has two engines of 100 H. P. set at 500 meters distance and plowing three to four hectares a day in good clean ground, about two feet deep and twice this in width of furrow (statement made by the foreman). In cogonal regions cable plows do not work as well as in cleared ground. Besides this objection it is found also that cogon when covered with soil takes a long time to rot, so burning the cogon before plowing is recommended. After plowing, a disc harrow may be run over the land. The making of the furrow is the next operation.

In cleared places and where steam plows could not be used a subsoil plow following the breaking plow in the same furrow was found to work well. This system of working is indispensable in some places for it not only breaks the land in the right way, but also offers satisfactory aeration of the soil, which is one of the important factors in the successful growing of cane.

Mr. May mentions that the ordinary mold board plow has given best results as used in Porto Rico, while the disc plow has not proven effective, especially in lands which are covered with grasses.[2] This should be substituted for the common Philippine plow, and greater animal power used. Our native plow with one animal can hardly produce the proper tilth of the soil. Perfect tilth has to be obtained, as far as possible, in the beginning, in order that future cultivation may serve simply for its maintenance. In places like the Philippines, where the fields have been under cultivation for a succession of years, they will surely be benefited if subsoiling is practiced to a depth of from 16 to 20 inches. This may be done by using a subsoil plow instead of the common native plow, immediately following the breaking plow in the same furrow.

The ground after being prepared with the necessary plowing is then disked once and harrowed and is thereafter ready for the setting of furrows. Furrows may be advantageously prepared at the time of planting the seed, because the soil is then moist and this will greatly facilitate the growth of the plant.

Selection of Seed Cane

The selection of seed cane is one of the most important problems and one which has never been given any attention by native farmers. This method of improving the industry is not only neglected in the neighborhood where this experiment was conducted but most probably all over the Philippines. On account of this negligence, together with the continuous cropping in the same fields without applying fertilizers and without proper plowing and cultivation, the cane grown naturally tends to decrease in size and in yield, instead of coming up to the highest standards, as should be expected in view of its long cultivation in the Islands.

The loss from poor seed cane is due to various causes. In the first place if the seed to be planted comes from poorly developed cane the offspring is sure to be uneven and poor. Poor canes possess weak buds and when planted will in many cases fail to germinate at all. Such seed will give many blank spaces and if it ever succeeds in growing will only produce slender and short-jointed canes. Such cane is said to be very susceptible to disease. The selection of good seed cane should then be considered of great importance among cane growers and only tops or cuttings

from vigorous canes should be used for planting.

To illustrate the desirability of selecting seed cane, an experiment was conducted in which the seed used was selected from the average best cane grown in Mr. Salva Cruz' cane field and planted in the same way, with a difference of distance in rows, and was given the same care as given by the native farmer. The following table indicates the result of the experiment.

Comparison between selected and unselected seed.

Los Baños White Bamboo Cane

Experimental distance of rows 80 cm. Native distance two feet or about 60 centimeters. All other methods the same.

Owner of canes	No. seed planted	Ave. length usable cane	No. cane produced	Prod. cane per stool
		cm.		
Selected seed	12	119.	86	3 to 18
Mr. Revilleza's cane	12	109.	27	1 to 5
S. Cruz cane	12	115.	29	1 to 7

Treatment of the Seed

The seed cane while in the ground, before any germination begins, is subject to the attacks of various enemies, and in order to guard against this destruction, certain precautions should be adopted. Mr. May in his bulletin No. 9, p. 15, states that excellent results have been obtained at the Porto Rico station by soaking the seed 24 hours in lime water. The seed is put in a tank, water run in and a few shovelfuls of lime thrown on. By comparison in the field such canes have germinated more readily and have been freer from disease.

In some places, cuttings are soaked for a few minutes in petroleum to keep them from insect attacks. Still better, the use of castor cake for manure, similar to the method followed by the Bombay cane growers, appears to greatly check the destruction. Kainit has been found beneficial in the same way.

On the college farm the only enemies to fear are ants and anay (termites). Cane seed soaked in water of course gives better germination than that not soaked at all. In our experiments soaked seed suffered far less from anay (termites) than unsoaked.

Rats also cause damage in the seed cane. Imported cuttings must be treated with fungicides, Bordeaux mixture for example, in order to be sure that diseases are not introduced with them.

Method of Planting

It has been the general practice in the Philippines to plant cane seed in a slanting position with the upper end near the surface or even projecting. To do this a pointed iron bar or a hard piece of bamboo is thrust into the furrow and in the hole made by this instrument the cane seed is placed and covered with dirt. The object of it is that the lower end of the cutting may reach the moist part of the ground. In this method three men are required for the work. One plowman prepares the furrow, followed by a man who drops the seed cane from a basket and a third man with the "panarak" who digs the hole and does the planting.

In Porto Rico according to Mr. May[2] p. 14, it is the usual custom to plant cane in holes cut with spades, and this is also done in some small plantings in the Philippines. As our labor is annually becoming scarcer and wages are increasing, it will be necessary to employ machinery to lessen the cost of the present method. Moreover, it appears that more efficient methods can be found, which not only lessen the cost but increase the yields. Furrows laid open with the plow are made at a lower cost than holes dug by hand.

"An experiment was made at this station (Porto Rico) comparing the hole with furrow method. In the first

plat three seed were planted in holes 7½ feet apart; in the second an equal amount of seed were planted 2½ feet apart in furrows; in the third plat the seed were planted in continuous row horizontally and wholly covered. The yields of cane per acre were as follows:

In holes ..... 36.6 tons.
In furrows, end to end .. 49.8 tons.
In furrows, continuous row ..... 54.1 tons.

The same bulletin mentions that on an experimental farm in India an experiment was tried to indicate the difference between furrow planting and trench planting, the result being that the former gave 24.5 tons of cane to the acre and the latter 31 tons. This led them to conclude that the furrow method should be substituted for hole planting. In some parts of the West Indies almost the same method is practiced as in the Philippines, the cane being planted in a hole made by an iron bar[3].

Judging from the cost of labor in the Philippines, a less expensive method must be adopted to replace the old Philippine method. An experiment was conducted to compare the planting of seed cane slanting (on end) in the furrow and flat in the furrow. Those which were planted on end were found to be injured by drought and attacked by white ants, while those planted flat in the ground were found to be less subject to any injury. Cuttings when planted on end are rather difficult to arrange so as to have the same uniformity of covering. Some may be well covered with soil while others have part of the upper end exposed at the surface. Some, especially in the dry season, may fail to grow at all on account of too rapid evaporation of the water from the cuttings. Cuttings planted flat in the ground have all the eyes receiving the same amount of moisture from the soil and are less attacked by insects. Another point in favor of flat planting is that it may be done at less expense and more rapidly than in any other way. A double moldboard plow opens a deep furrow and a man, dropping the seed cane in the furrow immediately after the opening, can cover the same by pushing the earth over the seed with his foot. If such an operation is not convenient a drag or covering machine may be run over immediately following the planting, to cover the seed. Another plow running near the furrow may also be used to cover the seed. The furrow made by this last plowing may be used to carry irrigation water if this is available.

The following table shows the difference between canes planted flat in the ground and canes planted slanting.

SINANDUYONG CANE

	No Seed Planted	No. da. Germ.	Percen. Germ.	No. Canes prod.	Yield per Ha.
					Kilos
Not Soaked Flat	50	15	100	465	44,385
Not Soaked Slanting	50	12	50	175	15,438
24 hrs. Soaked Flat	50	10	100	398	37,543
24 hrs. Soaked Slanting	50	8	62	146	12,631
48 hrs. Soaked Flat	50	10	92	255	27,192
48 hrs. Soaked Slanting	50	8	66	224	19,298
72 hrs. Soaked Flat	50	9	100	160	28,571
72 hrs. Soaked Slanting	50	6	84	130	18,932

Distance of Planting

In growing any crop, the main object of the grower is to obtain the maximum return from a certain piece of land with the least expense. Experiments carried out in many sugar cane countries have resulted in the recommendation of narrow planting. It is to be understood, of course, that the narrowest planting used in the best sugar countries is still

far wider than the native method in the Philippines. Here the general practice of the native grower is to plant cane one foot apart in the rows and two feet between the rows. Such a method prevents the root system from properly carrying out its function, on account of too little feeding space. This practice not only presents difficulties in the proper carrying out of the physiological function of the root system, but also to a certain extent checks the growth of backward plants. Shade from the larger plants cuts off the light which should reach the small plants. Ample spacing should therefore be practiced by the cane grower in order to properly facilitate the growth of plants; and this makes possible the use of modern implements for further cultivation.

In a Louisiana Station Bulletin[4] it is stated that in all their experiments they adopted five-foot rows except in the most highly fertilized plats, and in all, this distance gave very satisfactory results.

Wide spacing may be profitably used in the Philippines especially in fields where cane is being grown continuously. Combined with this, leguminous cover crops should be constantly in use. If cowpeas or velvet beans are grown, these germinate quickly and cover the ground in a period of from nine to ten weeks. The roots bear plenty of nitrogen tubercles, and the vines may be allowed to decay in the field or else fed to stock.

I have conducted an experiment on distance of rows and depths of planting as compared with the native method. The results, tabulated, are as follows:

COLLEGE PURPLE CANE.

Expt. Rows one and a half meter apart. Distance of planting in the row 50 centimeters.

(Native method 30 cm. in rows, 60 cm. between rows.)

Experiment cane yield per ha. in kilos	32,857
Native method yield per ha. in kilos	18,571

The cane when harvested was only ten months old. While young, both of these cultures were badly injured by locusts.

What Part of the Cane to Plant

Almost all cane growers use tops for seed purposes. Tops are chosen for seed purposes rather than the middle part of cane or the butts because of the belief that they give stronger and more rapid growth[4]. Tops may, of course, be had at a far lower price than the other two thirds of the cane. It has been proven also that the maximum of those constituents which are needed to nourish the young plants are to be found in the younger and tenderer portion of the stalk[4].

There are other cane growers who have different ideas in connection with the matter and who try to base their belief on the principles of plant physiology. "The cane," they say, "has only a few fertile flowers and consequently depends, for propagation, upon the eyes or buds. In all seed-bearing plants, those seed germinate and fructify best which are permitted to reach perfect maturity. Therefore, in imitation of this natural law, we must seek that part of the stalk which contains the largest and best developed eyes in order to secure seed which will produce the most vigorous plants. It is further claimed that where tops are universally used as seed a degeneracy of the seed will follow since the latter are always reproduced with these parts of the cane where the juices are poorest in nourishment (sugar) and the eyes most imperfectly developed."[4]

In this connection an experiment was conducted in Louisiana to find out what part of the cane would be best for propagation. The result obtained was that the tops were superior for seed purposes. Their understanding in this matter was that in the lower portion

of the cane fermentation often sets in after planting, thus checking and frequently preventing germination. The experiment was extended through a period of ten years, planting tops, middles, and butts. They found that no deterioration resulted either in the tonnage or sugar content.

In places where tops are needed for planting large areas, and there are not enough of them available, the best substitute is the butt of the cane. It would be better to use butts for seed than to let the ground lie idle as is done in many native fields. On some sugar estates, they never import tops or "puntas" which they use for planting their fields. This they avoid purposely because of the expense connected with it. During the time they are beginning to clear the field, they plant small lots with "puntas" and after three or four months they cut the canes and divide into three parts for further planting in order to produce more seed. This is continued until they secure all the seed they need to cover their entire fields and they thus escape the expense connected with the importation of "puntas." Such is the idea of the Calamba Sugar Estate and the Tunasan Sugar Central.

In order to be sure which part of the cane should be planted and what other parts may best be substituted in case of

COLLEGE PURPLE CANE

Rows one and a half meter. Distance of planting 50 cm.

	No. Seeds Planted	No. Suckers cane prod.		No. Seeds Planted	Suckers cane prod.
Not Soaked.			**Soaked 48 hours.**		
Tops-Flat 6 inches deep	12	115	Tops-Flat 6 inches deep	12	97
Tops-Flat 12 inches deep	12	138	Tops-Flat 12 inches deep	12	78
Tops-Slanting 6 inches deep	12	168	Tops-Slanting 6 inches deep	12	94
Tops-Slanting 12 inches deep	12	146	Tops-Slanting 12 inches deep	12	87
Not Soaked.			**Soaked 48 hours.**		
Middle-Flat 6 inches deep	12	65	Middle-Flat 6 inches deep	12	78
Middle-Flat 12 inches deep	12	47	Middle-Flat 12 inches deep	12	75
Middle-Slanting 6 inches deep	12	64	Middle-Slanting 6 inches deep	12	53
Middle-Slanting 12 inches deep	12	45	Middle-Slanting 12 inches deep	12	45
Not Soaked.			**Soaked 48 hours.**		
Butt-Flat 6 inches deep	12	75	Butt-Flat 6 inches deep	12	106
Butt-Flat 12 inches deep	12	68	Butt-Flat 12 inches deep	12	80
Butt-Slanting 6 inches deep	12	75	Butt-Slanting 6 inches deep	12	71
Butt-Slanting 12 inches deep	12	87	Butt-Slanting 12 inches deep	12	45
Soaked 24 hours.			**Soaked 72 hours.**		
Tops-Flat 6 inches deep	12	106	Tops-Flat 6 inches deep	12	95
Tops-Flat 12 inches deep	12	71	Tops-Flat 12 inches deep	12	90
Tops-Slanting 6 inches deep	12	123	Tops-Slanting 6 inches deep	12	63
Tops-Slanting 12 inches deep	12	106	Tops-Slanting 12 inches deep	12	58
Soaked 24 hours.			**Soaked 72 hours.**		
Middle-Flat 6 inches deep	12	86	Middle-Flat 6 inches deep	12	41
Middle-Flat 12 inches deep	12	69	Middle-Flat 12 inches deep	12	43
Middle-Slanting 6 inches deep	12	54	Middle-Slanting 6 inches deep	12	40
Middle-Slanting 12 inches deep	12	50	Middle-Slanting 12 inches deep	12	42
Soaked 24 hours.			**Soaked 72 hours.**		
Butts-Flat 6 inches deep	12	54	Butts-Flat 6 inches deep	12	43
Butts-Flat 12 inches deep	12	67	Butts-Flat 12 inches deep	12	86
Butts-Slanting 6 inches deep	12	60	Butts-Slanting 6 inches deep	12	73
Butts-Slanting 12 inches deep	12	50	Butts-Slanting 12 inches deep	12	65
Cane No. 299	1	19	Cane No. 897	1	19
Cane No. 896	1	11	Cane No. 70	2	4

necessity, an experiment was conducted on the College farm in which tops, middles, and butts were planted immediately after cutting, some being soaked in water for 24 hours, 48 hours, and 72 hours respectively. In each of these sets, depth of planting and the manner of planting were varied with tops, middles, and butts. Some were planted six inches deep, and 12 inches deep, flat in the furrow. Others were planted six inches and 12 inches deep and slanting. From the data obtained in this experiment, it was found that the top is the best part of the cane for seed and the butt is the next best if soaked 48 hours before planting. In this set of experiments all seeds which were not soaked at all gave a greater growth and sucker production than any which were soaked in water. As to the depth of planting my results vary considerably. Out of those which were not soaked at all and those soaked 48 hours, those which were planted 12 inches deep gave greater growth and sucker production than those planted 6 inches deep. It is our experience in the matter that tops and butts give the greatest percentage of germination and greatest number of suckers, favored probably by the more numerous eyes borne by them. In regard to the depth of planting, if the ground is previously irrigated and well pulverized, cane will grow just as well planted six inches deep or 12 inches deep, if planted flat.

Desirability of Introducing New Varieties

Many farmers when already in possession of a single variety of cane do not take the trouble to obtain others. They never seem to realize that there may be other and better canes. The sugar content of a cane does not depend solely upon the soil and climatic conditions, but also on the inherent qualities peculiar to certain varieties. Looking at it from this standpoint it is quite reasonable to conclude that other kinds of canes should be introduced into the Philippines, canes of good quality, both in size and yield per hectare. The introduction of canes possessing a high saccharine content might bring a higher profit to land owners, over any of those now grown. Canes continuously grown in one hacienda may become infected by certain diseases and after a long continued cultivation, the destruction might prove fatal to profit. In such cases, the desirability of introducing resistant varieties and varieties of known vigor and productivity is very apparent.

In the present experiments there are eight varieties of canes. Of these eight varieties only one is grown throughout the vicinity where this experiment was conducted. It is true that this one proves to be the best in production among the seven varieties.

Diseases

Cane, like any other plant, becomes infected with diseases any time from the start until maturity. In the seed condition it is liable to be attacked by crickets, ants, and anay. However, to be free from these insect attacks, seeds may be protected by soaking in petroleum for a few minutes or in Paris Green-Bordeaux mixture or by an application of kainit before planting. In the case of ants mere soaking in water is found to be a deterrent, but it will not do any harm to apply some more radical preventive measures.

Fungus diseases were found to be attacking canes used in the present experiments. Among them are Cercospora acerosa attacking the leaves of almost all the varieties. This fungus attacks the midrib of the leaves near the base, producing red spots and as a result the midrib easily breaks with a

slight wind. Coniothyrium sacchari is another fungus which attacks the leaves of the canes and is found on the college purple cane. Possibly, by plowing in all the trash and liming the ground very heavily afterwards, trouble with these fungi could be obviated.

Harvesting

It has been found that stripping the canes before harvesting involves less labor than to harvest them without having been stripped. If stripping is performed canes could be easily topped and cut as low as possible and could be placed in rows or at once in the wagon for hauling to the mill.

In the present experiment several points were considered in the matter of deciding which variety would give the highest tonnage of cane per hectare and which variety would bring the highest profit to the grower. The data obtained are tabulated as follows:

	Sinanduyong purple cane	Los Baños white bamboo	Zambales	College purple cane
Average length of harvestable cane	150 cm.	140 cm.	190 cm.	100 cm.
Average weight of one cane	1140 gr.	1300 gr.	1960 gr.	700 gr.
One meter of cane weighs	780 gr.	880 gr.	1140 gr.	700 gr.
Harvestable cane of one ave. plant weighs in kilos.	7	8	12	4
Average number of canes to a plant	6	8	5	8
Number canes per hectare	49547	82250	44035	99473
Weight of cane per cane in tons	25.69	63.63	50.70	33.16

Note: The first three varieties in this table were planted May 10th, 1913, and harvested March 2nd and 3rd, 1914. The last variety, the College purple cane, was planted May 20th, 1913, and harvested March 3rd, 1914. All of these canes were badly injured by locusts.

Summary

1. Production may be increased by using "seed" taken from strong plant canes.

2. Yield and percentage of germination may be greatly increased by planting seed flat in rows instead of planting slanting.

3. Seed planted 12 inches deep when planted flat did better through the dry weather than when planted 6 inches deep in the same manner. Also, seed 12 inches deep planted slanting did better than 6 inches deep planted in the same way.

4. Seed from Los Baños white bamboo cane did best in the college farm in cane production. Zambales comes next in cane production and tonnage per hectare, though this is not a good milling cane.

5. Tops may be grown successfully when planted at once after cutting even if not soaked at all. In all the tests made tops which were not soaked in water and those soaked in water did better than the other thirds of the cane. Butts may be planted to advantage if soaked in water for 48 hours.

Biliographical References

[1] Bulletin, Cultivation of Cane in the West Indies, p. 15.

[2] Bulletin, Porto Rico, p. 14, No. 9.

[3] Cultivation of Cane. Bulletin German Kali Works, p. 22.

[4] Cultivation of Cane in Louisiana, by Dr. Stubbs, p. 104-106.

[5] Sugar Cane in Negros, by Walker, p. 82-91.

[6] The Sugar Industry of the United Provinces of Agra and Oudh, pp. 3-12.

[7] The Sugar Cane in Egypt by Tiemann.

[8] Cultivation of Sugar Cane by Spencer.

UNIVERSITY OF THE PHILIPPINES

COLLEGE OF AGRICULTURE

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For further information address the Dean of the college.